

every point of the immersed surface of a ship, upon the lines and speed being given, is one which will long remain to be solved; but every step towards that end must be of interest, and the best way to proceed is naturally to divest the subject of those elements which tend to obscure its solution, and thus grapple with difficulties in detail. This the author proceeds to do by imagining a set of conditions which by no means exist. Thus, he supposes the surface of the water covered by rigid smooth ice, and the vessel to be flat-bottomed with vertical sides. In this way similar water lines are obtained, and the flow of water will be in plane stream lines only. This simplifies the work, since the methods and formulæ dealing with stream lines in two dimensions are much simpler than those for stream lines in three dimensions. The author proceeds to work out his problem on these lines at some length, and it will be evident from what has been said that it would be impossible to deal adequately with the question in a report such as this; in fact, the paper requires more study than we have been able to give to it up to the present. A short discussion followed the reading.

Mr. Stromeyer's paper discussed steam pressure losses in steam-engines due to various causes, such as friction of steam in pipes and passages; the spring of eccentric straps, rods, and links; inaccuracies in slide valve motion; piston leakage; throttling of steam, &c. Mr. Croll's paper dealt with a subject that has occupied the attention of marine engineers for some time past—the best method of working engines at lower powers; and Mr. Joy described his arrangement for reversing engines by means of an hydraulic cylinder placed inside the eccentric, so that an effect, in some respects, similar to that obtained by means of the loose eccentric is reached without the uncertainty of the latter device, and also with the further benefit of being able to “link up” or to stop the engines by making the eccentric disc coaxial with the shaft. The arrangement is certainly a very taking one, and appears to promise well, though of course such a tried device as link motion will not be ousted until any new arrangement has thoroughly proved its superiority.

The meeting terminated with the usual votes of thanks. The summer meeting will be held at Southampton, in July.

CHOLERA.¹

IF anyone had undertaken, thirty years ago, to classify the communicable diseases according to whether they are easy or difficult of prevention, he would have doubtless placed cholera, the disease I have chosen for the subject of this lecture, in the front rank amongst the non-preventible, or, at any rate, amongst those diseases that are preventible with very great difficulty; while, if anyone were at the present time to revise this classification, he would find himself in the fortunate position of placing cholera in the front rank amongst those diseases that are easily prevented; in fact, he would be able to tell you that the prevention of the spread of cholera is beset with less difficulty than that of some of the communicable diseases which in towns we have almost constantly among us, as, for instance, pneumonia, diphtheria, measles, and scarlet fever. Nothing could more forcibly illustrate the great advance in practical sanitation than the comparative immunity from cholera in an epidemic form, which this country has enjoyed for the last twenty-five years. By saying “comparative immunity,” I am not forgetting that we have had cases of Asiatic cholera in this country during the last autumn, and it is precisely the remarkably limited character of this last outbreak which furnishes the best proof of our advance in sanitation, and gives satisfactory evidence of the correctness of the views on which the measures adopted for the prevention of the spread of cholera are based, and of the justification of placing cholera amongst the easily preventible diseases. To give you an idea of what sanitation has been able to do, and the complete success which attended the practice of good sanitation in preventing the spread of cholera, I will quote in illustration the following remarkable instance:²—A well-known fact which has received, unfortunately, a great many illustrations, is this: that pilgrims in India carry the contagium of cholera from the fairs or festivals, to which the disease is brought from the endemic area, to localities which were

previously free from cholera. One such fair is particularly notorious, and it has in the past always been a source of the utmost anxiety to the Government of India; this is the great religious festival or Kumbh fair of Hardwâr, a town on the Ganges, but situated outside the endemic area of cholera. This great Kumbh occurs once in twelve years, and it is attended by large numbers of pilgrims, a proportion of these coming from districts in which cholera is always endemic. It has thus frequently happened that this great concourse of pilgrims has been followed by a wide diffusion of the disease. The great Kumbh is principally a religious festival, and is looked upon by Hindus as one of peculiar sanctity, and the very aim and object of their pilgrimage is to bathe in the sacred Ganges, and drink of its holy waters. In 1891, when the last Kumbh fair was held, 800,000 to 1,000,000 pilgrims assembled in Hardwâr; and to get an approximate estimation of the enormous pollution to which the sacred Ganges at Hardwâr is on this occasion subjected, and the great risk from cholera to which those who drink of its waters are exposed, I will mention what Dr. Simpson, the able health officer of Calcutta, states. In describing the scene at the “sacred pool” at Hardwâr—somewhat retired from the rest of the river—to bathe in which and to drink whose waters the pilgrims gather together in such multitudes, Dr. Simpson states that as the bathing of the pilgrims went on the clear stream became a muddy one; that from April 8 to 12 there was always passing through the sacred waters a “seething mass of humanity” in constant motion, passing through the pool at the rate of 400 to 500 per minute. You can easily picture to yourself that a few cases of cholera introduced into such a multitude, living under such conditions, would easily cause not only an outbreak of cholera there and then, but would by the returning pilgrims be carried far and wide. Thus a sanitary commissioner says of the Kumbh, previous to 1867: “Very little remains on record, but that little is a record of disease and death.” In 1867, and again in 1879, the festival was followed by an epidemic outbreak of cholera, which on the latter occasion rapidly extended to the western districts. Now, all through the winter of 1890-91 there was much cholera in the north-west provinces and along the pilgrim routes below the hills. So grave was the outlook, that the question of prohibiting the fair to be held in April, 1891, was seriously discussed, and the official opinion of a civil-surgeon, in conformity with that of many other officials of great experience, was to the effect that “the most complete sanitary arrangement will be powerless to prevent the spread of cholera should the contemplated fair at Hardwâr be permitted to take place.” Now mark what Mr. Ernest Hart says:

“The fair took place in April, 1891. In December, 1890, proceedings began at and about Hardwâr by the construction of seven bridges, by means of which access to the sacred pool from various parts was much facilitated. The whole of the site was then cleared of undergrowth, all filth was scraped away and removed, and arrangements made for the trenching of night soil. A small army of 1342 sweepers was engaged, and means were taken to prevent their desertion, an event which previous experience had shown to be not unlikely. The whole site was divided into sanitary sections, each with its temporary hospital and its sanitary patrol, every constable of which had his own fixed beat, within which he was instructed to (1) prevent overcrowding, (2) see to surface cleanliness, (3) give notice and remove nuisances, (4) report offenders, (5) remove those sick of infectious diseases, (6) see to the proper location of animals. The sanitary, police, and medical sections were made to correspond, each section being equipped with a special hospital, a number of constables, sanitary inspectors, an ambulance, and a large staff of conservancy men. Each section was thus complete and self-contained, and was directly responsible to the sanitary and deputy sanitary commissioners for the conditions of its own area. The members of the sanitary patrol had each their given beats, over which they exercised a constant supervision, acting also as detectives for sickness.

“The key to the sanitary management of the fair lay in the searching out and rapid removal of all cases of suspicious disease, in the maintenance of perfect cleanliness in the camp, and in the measures taken to prevent all possibility of contamination. Various improvements, however, were made in the conduct of the bathing festival, which were no doubt of great importance.

“The pilgrims coming from cholera-infected districts brought the infection with them, and two people died of undoubted cholera at Hardwâr during the most crowded period, but they were promptly isolated, and the infection did not spread. No

¹ A Lecture delivered at the London Institution on February 15, 1894, by Dr. E. Klein, F.R.S.

² This account is taken from Mr. Ernest Hart's description in the *Daily Graphic*, September, 1893.

more cases arose in the town or camp, nor did the disease develop on the track of the dispersing pilgrims. And thus we had the novel experience of a Kumbh fair at Hardwâr without an epidemic of cholera spreading all over the surrounding country concurrently with the dispersion of the gathering."

This is unquestionably one of the most remarkable and brilliant achievements of sanitation in the whole history of cholera. Not only in India, but also in Europe, has it been demonstrated that cholera is a preventable disease. The history and character of the epidemic which prevailed in France, Italy, and Spain between 1884 and 1886, and in Russia in 1892 and 1893, was in no way different from what it used to be thirty years ago in other European countries; it is expressed by stating that the population of villages and towns of whole districts were smitten by disease and decimated by death. But it was different with England and Germany. In 1892 cholera broke out in Hamburg, and asserted itself with great severity; the insanitary conditions of its dock and port population, the neglect in supplying Hamburg with wholesome drinking water—Hamburg being then supplied with unfiltered, polluted Elbe water—brought for Hamburg the long-predicted day of reckoning. In former years the establishment of such a focus of cholera as Hamburg, having such vast communications and intercourse with the whole of Germany, would have been followed by innumerable foci of cholera all over Germany; yet we have the remarkable fact that, with the exception of few cases in a limited number of towns, Germany did not suffer from any further epidemic outbreaks. And in a perhaps more striking manner was the same fact illustrated in 1892, here in England. Grimsby, and Hull also, had cases of cholera in 1893, the former officially at the commencement of September, unofficially some weeks before. The sanitary condition of Grimsby, as revealed at the time by inquiry, and published by the *Times* and the *British Medical Journal*, remind us, in some respects, almost of the times and conditions of a former generation, and the result, as was to be expected, was an unnecessary loss of life through cholera. But although Grimsby carries on a considerable trade by rail and sea with the rest of England, and is in notoriously extensive personal railway communication with the rest of the northern and midland counties (*vide* the enormous fish and oyster trade of Grimsby and Cleethorpes, and the extensive tourist communication with Cleethorpes), with two or three exceptions in which a small local outbreak occurred (Ashbourne, Derbyshire; Rotherham, Yorkshire; North Bierley, Staffordshire), only isolated cases of cholera were noticed in the rest of England. What is this comparative immunity due to, what is the cause of the conspicuous limitation of cholera, that has been experienced lately both in England and Germany? In both countries foci of cholera had been established, sufficient, judging from former experience, for the dissemination and production of cholera in an epidemic form in numbers of localities, and although the transmission and spread of cholera from the first foci, owing to the increased facilities of human intercourse, was possible in a greater degree than in former periods, yet the country remained practically free from cholera epidemics.

Sir John Simon has years back insisted on the importance of considering cholera, as also typhoid fever, as a "filth disease"; that is to say, both in cholera and in typhoid fever the contagium voided with the dejecta of a patient, affected with the one or the other disease, is capable of setting up the disease, if it finds access to the alimentary canal of a susceptible person, either by specifically polluted drinking water or articles of food, or by the instrumentality of the hands that had been in contact with specifically soiled linen or other textile articles.

Since the recognition of these facts it has become an axiom in sanitary science to isolate the patient, to disinfect or destroy not only the dejecta, but all articles that may have become soiled by the dejecta of a patient affected with cholera, to prevent such filth from gaining access to drinking water and to articles of food, and to insist that the hands that have been in contact with such soiled articles ought to be scrupulously cleansed in order to avoid self-infection; in short, to prevent and to avoid the contagium being "swallowed." By carrying out these precepts it has become possible, and, as events proved, it has been successfully accomplished that cholera did not spread epidemically either at the last Kumbh fair at Hardwâr, or in England or in Germany. This success implies two things: (1) the locality, prior to the introduction of a case of cholera, should

be in a proper sanitary condition, and (2) on the appearance of a case of cholera the measures for isolation and disinfection should at once be put in practice; there should be no attempt at hiding or ignoring, but boldly and openly the fact should be recognised, and action taken accordingly; for if in any locality even a few cases are allowed to pass undealt with, and supposing the sanitary conditions of that locality be of an inferior character, the dissemination of the contagium and the creation of a number of further and independent foci may in a short time bring about a state of things in which the check of the epidemic spread of the disease becomes a matter of the greatest difficulty—an occurrence which had its illustration both in Hamburg and in Grimsby. Though a great portion of England may claim to be fairly well prepared, as far as general sanitation, drinking-water, drainage, and general cleanliness are concerned, it is notorious that there remain localities which escaped a visitation by cholera during last year; but their luck may not hold out on a second occasion, and a day of reckoning may arrive on which they will be rudely awakened, like Hamburg, to the fact that by their negligence in the past they have to pay a heavy penalty in human life.

Now, it will be asked, is it a fact that those isolated cases which occurred in different localities in England during the last autumn were really cases of true or Asiatic cholera, and that owing to the better preparation and stricter execution in regard to sanitary measures, insisted on by our Public Health authorities, those isolated cases did not spread, and were not followed by further outbreaks of the disease? It must be evident that if those cases were not cases of true cholera—that is to say, if they were of the character of that disease which occurs in each year during the summer and autumn in a sporadic form, known as English cholera or cholera nostras, then the above proposition as to the supposed superiority of our sanitation for the prevention of the spread of epidemic or Asiatic cholera remains as yet untried and has still to be proved. No one, I presume, will deny that we had in September, 1893, true or Asiatic cholera in Hull, Grimsby, and certain other places; the character of the disease, the grouping of the cases, and the high percentage of mortality prove this; besides, it is known that cases of cholera have reached our shores both in 1892 and 1893. Similarly, it will not be denied that the cases that occurred in Rotherham, Ashbourne, and North Bierley were of the same nature; the symptoms, the epidemic character, and the high fatality alone prove this. But what has been questioned is whether the isolated cases which occurred in Retford, Leicester, Derby, Doncaster, Yarmouth, London, and other places, were true cholera. Now, it is agreed that as regards their clinical history and mortality (these were all fatal cases) a distinction between them and typical true cholera could not be drawn. But it is said that (a) on account of their occurring as isolated cases, and (b) on account of the impossibility of tracing the way in which the infection had been imported, the proof that they were cases of true cholera has not been satisfactorily established.

As to (a). If in any locality after the appearance of one or more suspicious choleraic cases there should follow, sooner or later, a gradually increasing number of similar cases with high fatality, the preliminary conclusion that these are cases of true cholera is justified. But whether in any locality one case is followed by others, or remains an isolated one, obviously depends on the condition whether the contagium, either by the prevailing insanitary conditions, or by the laxity of the application of sanitary measures, has or has not been allowed to take a footing and to spread; for if, as stated above, the conditions as to drinking water, drainage, &c. are satisfactory, and if on the introduction of the first case this is at once isolated, its dejecta disinfected and destroyed, and infection from it therefore prevented from being disseminated, it is clear that no further cases would be forthcoming. The epidemic diffusion of the disease depends then on deficient sanitation, and cannot therefore be a distinguishing character between what is true and what is not true cholera. No one doubts that the few cases that were imported from cholera-infected districts in 1891 into Hardwâr were cases of true cholera, yet we saw that owing to the excellent and thorough sanitary measures taken before and during the fair no epidemic occurred; those few cases therefore remain cases of true cholera, notwithstanding the unwonted absence of an epidemic outbreak.

In a like manner it must be evident that numbers of persons that contracted the infection in Hamburg in 1892 travelled to many places in Germany where they sickened of, and some of

them succumbed to, the disease; others came over to England and to London, yet they did not produce an epidemic in the localities in which they arrived or died, for the simple reason that they were looked after, isolated, and their dejecta and belongings disinfected or destroyed. But they do not cease to be cases of true cholera, though they were not followed by others.

The following case, that occurred in England last September, may serve as an illustration. A man, landlord of an hotel in Retford, who for some days was suffering from diarrhoea, had been to Doncaster, where he partook of oysters brought from a cholera-infected locality. Soon after arriving home he was seized with violent cramping pains of the arms and legs, sickness, vomiting, and diarrhoea; the doctor who was called in noticed the altered voice, which was like a whisper; the patient was very restless, and complained of great depression; the evacuations were like rice-water, there was suppression of urine; he rapidly became collapsed, the extremities became cold, and the surface of the body livid and shrunken. He died after an acute illness of fifteen hours and a half. I have read to you the clinical history of this case because it presents the picture of true virulent cholera, such as is described in text-books as a most typical case of Asiatic cholera. It is presumable that the above person became infected by eating oysters, because these were derived from a place where cholera was rife, but it is only presumably so; the man had not been either at Grimsby, Hull, or Cleethorpes, or any cholera locality; but that he suffered from, and succumbed to true cholera, can hardly be doubted, and I shall give you presently further evidence to that effect; and yet this remained, thanks to the prompt sanitary measures taken, the only case of cholera that occurred at Retford. You see, then, that a case remaining an isolated one does not necessarily cease to be a case of true cholera.

As to (b). As regards the inability to trace every one of the isolated cases that occurred in the different localities to a previous focus of cholera, and the allegation on this ground that it remains doubtful whether these cases were or were not true cholera. It is unquestionably a great help, in order to make a correct diagnosis and to take the necessary precautions, to trace the manner in which the infection found entrance into a given locality. But, unfortunately, the way in which the contagium of cholera, as well as that of typhoid fever, travels, is not always a straight one or easily followed; in many cases the way can be followed with approximate accuracy, but in others—amongst them some epidemics of undoubted true cholera—the manner in which the contagium was introduced has baffled even experienced sanitarians, and it is owing precisely to such instances (they have occurred both in India and in Europe), that the solution of the problem as to the origin of some of those cholera epidemics is beset with great difficulties, and has called forth a division of opinion amongst epidemiologists. If the problem were of such simplicity as is implied by the assertion, that in every case of cholera we must be able to trace the infection to a known focus, the division of opinion as to the origin of some of the epidemics of true cholera would long ago have disappeared.

Koch first showed that in the rice-water-like dejecta and in the rice-water-like contents of the intestine of a typical case of Asiatic cholera, there occur certain bacteria, which, on account of their shape, were called by him comma-bacilli; he showed that in some of the typical cholera cases, in which the dejecta or the intestinal contents are of what is called rice-water-like character (that is to say, in a more or less translucent fluid are suspended large and small flakes, composed of the detached epithelium lining of the intestinal mucous membrane), the flakes, as also the fluid, contain these comma bacilli in enormous numbers; and that the flakes contain them in a characteristic linear arrangement, occasionally to the total exclusion of other kinds of bacteria, such as may be found inhabiting the normal alimentary canal.

I exhibit here on the screen photographs of the microscopic character of the rice-water-like dejecta of typical cases of Asiatic cholera; one from a case in India, several from typical cases that occurred last year in England. The illustrations show not only a great number of the comma bacilli and a total exclusion of other bacteria, but also the characteristic linear arrangement of the vibrios in the flakes.

It is now agreed by all who have devoted attention to this subject, that such a condition as I have shown you here does not occur in any other acute disease of the alimentary canal in man except in Asiatic or true cholera. A large number

of cases of cholera nostras, or English cholera, have been subjected to examination abroad and in England in non-cholera years, and the result was always the same—viz. a condition such as I described and showed to you does not occur in them. So much so, that all pathologists agree that, supposing a case presents the principal symptoms of cholera, inclusive of the rice-water-like dejecta, if the flakes suspended in the fluid portions of the dejecta show under the microscope crowds of the comma bacilli, particularly in the above linear arrangement, the diagnosis “true cholera” is fully justified. Whether a case of this kind is an isolated one, and whether we are able or unable to trace the way in which the infection has come about, does not, to my mind, alter the diagnosis in the slightest degree. We may be successful in putting our finger on the probable or demonstrable path on which the cholera infection travelled, or we may be baffled in this attempt; we may say—as in the cases that occurred in Hull and Grimsby, in Rotherham, Ashbourne, North Bierley, and elsewhere—here we have a succession of cases presenting all the clinical and pathological characters of true cholera, showing the high fatality found only in true cholera; the flakes of the rice-water-like evacuations show the microscopic characters observed only in Asiatic cholera; therefore we are dealing with true cholera, and we do not further trouble ourselves (for the object of making correct diagnosis) with finding out how the first case was introduced, particularly if we remember that most of these places, owing to their situation, may have been exposed to importation of the contagium from cholera-infected localities. Or we may say, as in the Retford case, we presume that the patient, having partaken of oysters which came from an infected locality, caught the infection through these oysters, and the case, presenting all the clinical and pathological characters of virulent true cholera, and the flakes of the intestinal contents showing the microscopic characters found only in Asiatic cholera, must be one of true cholera, notwithstanding that the case is for Retford an isolated one. But I fail to see how the assertion can be justified, that has been repeatedly made during the last autumn, of various isolated cases occurring in different localities—Leicester, Derby, Westminster, and others—viz. the assertion that these cases, which were all fatal, which presented the symptoms and pathology characteristic of virulent true cholera, and which showed in the flakes of the rice-water-like dejecta the microscopic appearances characteristic of, and found only in, true cholera. The assertion, I say, that these cases cannot be true cholera, because we were not able to trace the manner in which infection was introduced, and because they have not been followed by other similar cases, cannot be accepted.

I take for illustration the noted case of the woman, the cleaner in the House of Commons; she died in Westminster last September, after a very short illness; the symptoms were those of true cholera; the pathological condition of the intestine, the microscopic character of the flakes of the rice-water-like dejecta were such as are found only in typical cases of true cholera, and in no other known acute disease of the intestine; but the manner in which she contracted infection could not be discovered, nor was this case followed by others; rigorous sanitary precautions were at once applied to the house in which she lived and all that appertained to it.

I show you here the microscopic character of the flakes of the rice-water-like dejecta of this case, and you can see that it presents in a conspicuous degree the characteristic appearances, both as to the number and arrangement of the comma bacilli.

The comma bacilli, derived from cases of Asiatic cholera, when tested by cultivation under the different conditions, such as are used in the laboratory for distinguishing one species of bacteria from another, are admitted on all sides to represent a definite group of organisms, of which the principal distinguishing characters in cultivation and in microscopic specimens are shown in these photographs.

One character of particular interest which these cholera vibrios, or cholera spirilla, or Koch's comma bacilli show, is their behaviour when grown at the body temperature (37°C.) in a solution containing peptone and salt; in this solution they grow well and multiply very rapidly, and produce in it nitrites and indol; the presence of these products can be demonstrated already after a few hours (6–8) by adding to the culture a few drops of pure sulphuric acid; the culture at once assumes a distinct rose-coloured tint; this reaction is called the cholera-red reaction. Now, there are known other species of comma

bacilli or vibrios, which in shape, size, motility, manner of growth in the different media, more or less resemble the cholera vibrios of Koch. Some of them also give the cholera-red reaction, sooner or later, when grown in peptone salt culture.

But there is at present known only one comma bacillus from the diseased human intestine that shows certain cultural characters, that grows at 37° C. in peptone salt cultivation with great rapidity, and gives in very short time the distinct cholera-red reaction; and this is the comma bacillus of Koch, found by him in the human intestine in Asiatic cholera. From this it follows that if in any case of choleraic disease this particular species should by microscopic examination, and by the culture test, be demonstrated as present in the bowel, the conclusion is justified that we are dealing with true cholera.

In those isolated fatal cases of choleraic disease which occurred in different localities in England during last autumn (Leicester, Derby, Westminster, Doncaster, Yarmouth, and others), apart from the symptoms and the pathological conditions of the intestine and the characteristic microscopic appearances as to the distribution of the comma bacilli, this species of vibrio was demonstrated by cultivation, and therefore we are justified in saying that these cases were of the true or Asiatic type, and we are further justified in saying that it was owing to the prompt action of the sanitary authorities that these cases were not followed by epidemic outbreaks.

But while we can state from the bacteriological examination that a particular case is true cholera, we cannot affirm with equal reliability whether this comma bacillus plays any and which rôle in the causation of the disease; nor that a case in which the bacterioscopic examination does not demonstrate the presence of Koch's vibrios in the intestinal discharges is not true cholera; and this for the important reason that in various epidemic outbreaks of true cholera there occurred in the same locality and at the same time, side by side, with undoubted cases of Asiatic cholera, and presenting the same clinical symptoms, the same pathology, and the same high death-rate, a certain proportion of cases in which Koch's comma bacilli could not be demonstrated. In what respects the bacteriology of such cases differs from cases of sporadic or English cholera, is a subject for future inquiry; at present no sufficient data are at hand.

GEOLOGICAL SURVEY OF THE UNITED KINGDOM.¹

I.

ENGLAND AND WALES.

Drift Survey.—In the early maps published by the Survey, superficial deposits were generally left unrepresented. The importance of these deposits in questions of agriculture, drainage, water-supply, and public health having at length been recognised, it was determined that in future they should be traced and shown upon the maps. As at first they were inadequately understood by geologists, the mapping of them could not be made wholly satisfactory and complete. But as they came to be more thoroughly studied and more carefully traced, they have been represented with increasing fulness and accuracy upon the maps. It has been thought desirable to revise and complete the earlier drift surveys in the north of England, and to extend these surveys over the other parts of the country where they have not previously been made. This renewed examination of the ground is carried on upon maps of the scale of six inches to the mile, and advantage is taken of it to check, and where needful to correct, the already published mapping of the older geological formations underneath.

As the Geological Survey advanced into the eastern counties of England, the importance of the drift deposits became increasingly manifest. Over large districts indeed it was impossible satisfactorily to delineate on maps the structure and boundaries of the formations underlying the drifts which spread as a deep cover above them. For such areas drift maps only could be issued.

¹ Annual Report of the Geological Survey for the year ending December, 31, 1892. By Sir Archibald Geikie, F.R.S., Director General. From the Report of the Science and Art Department for 1892. (Some of those portions of the Report which describe the scientific results of the Survey operations during the last few years are reprinted here.)

It was not until the original survey of the whole of England and Wales had been completed that the systematic re-survey of the drifts was begun on the six-inch scale, over those areas not previously surveyed for this purpose. In the south-east of England, where the work is under the charge of Mr. Whitaker, it has extended from Huntingdonshire across the counties of Bedford, Hertford, Buckingham, Oxford, Berks, Wilts, Hants, and the south of Sussex.

Tertiary.—The re-examination of the Tertiary areas to the west of London for the Drift Survey has shown the general accuracy of the old mapping, though the boundary-lines have been occasionally improved. In Hampshire and the Isle of Wight more extensive alterations have been necessary. Thus, the Hamstead Beds, in place of occupying mere isolated patches on the high ground, as was believed when the original map was prepared, are now known to cover a large area. This was proved by Mr. Reid, chiefly by the use of portable boring-rods, such as had for some time previously been employed by the Belgian Geological Survey. These tools have also proved of great service in some recent work in the eastern counties. Certain small outliers on the Chalk of Hampshire, shown as Eocene on the old map, have now been placed among the drifts, and have been mapped as "Clay-with-flints." Probably here, as is often the case in parts of the London Basin, the so-called "Clay-with-flints" is in great part re-arranged Eocene material.

Cretaceous.—On the older one-inch maps the Chalk was shown as one mass, no attempt being made to indicate its subdivisions. Indeed no such subdivisions were formerly recognised, save a general grouping into Chalk-with-flints and Chalk-without-flints. Sometimes the lowest portion was separately referred to as Chalk Marl. In later surveys, however, advantage has been taken of the opportunity of tracing on the ground the subdivisions that can now be mapped. These are as follows:—

Upper Chalk.

Chalk Rock.

Middle Chalk, with Melbourn Rock (at the base).

Lower Chalk, with Totternhoe Stone.

Chalk Marl.

The separation of the thick mass of Chalk into so many distinct subdivisions has both an economic and a scientific interest. By revealing the actual structure of the Chalk and the outcrops of its several members the new mapping renders essential service in questions of water supply. It likewise indicates the undulations into which, in consequence of subterranean disturbances, the Chalk has been thrown. These undulations, though often too gentle to be safely inferred from surface exposures, are apparent when the outcrops of the several subdivisions of the Chalk are continuously traced.

In the Chalk-area of Hampshire, Mr. Hawkins, by mapping out these horizons, has proved the general accuracy of the interpretation of the structure of that region given by Dr. Barrois. The uprise at Winchester is well marked, Lower Chalk being there brought to the surface. The folds traversing the Chalk in the western part of the Hampshire Basin, though more strongly marked than those of the London Basin, can only be satisfactorily made out by mapping the subdivisions of the Chalk. Some of the ruptures attendant on the plication of the rocks, so marked in Dorsetshire, are prolonged even into Sussex, and have been detected by Mr. Reid as far east as Eastbourne, where on the foreshore the Cretaceous strata are repeated by faults and over-thrusts.

It seems not impossible that the detailed and accurate mapping of the disturbances in the Chalk may ultimately give a clue to the depths of the underlying Palæozoic rocks, a question of the utmost practical importance in regard to the tracing of coal-bearing deposits beneath the south of England.

In 1891 phosphatic Chalk, closely resembling that which is commercially worked in the North of France and in Belgium, was noticed for the first time in this country by Mr. Strahan. The bed is exposed in a Chalk-pit at Taplow, but at present has not been detected elsewhere.

The relations of the Gault and Upper Greensand have long been a matter of uncertainty. Mr. Bristow, the late Senior Director, believed that the two were really one formation, one being locally developed at the expense of the other. Mr. Godwin-Austen regarded the Upper Greensand as a shore-deposit, in part contemporaneous with the Gault of deeper waters. Other geologists have expressed similar views. These